Counting statistics-based Bell inequality for entangled electrons

Fabio Taddei(1,2), Lara Faoro(1) and Rosario Fazio(2)
(1) *ISI Foundation, Viale Settimio Severo, 65, I-10133 Torino, Italy*
(2) *NEST-INFM & Scuola Normale Superiore, I-56126 Pisa, Italy*

Entanglement [1] denotes the non-local correlations existing, even in the absence of interaction, between two (spatially separated) parts of a given quantum system. Besides its fundamental interest, great deal of interest has been brought forth by its role in quantum information [2]. Only recently people have started to study how to generate and to manipulate entangled pairs in a solid state environment.

It has been shown [3] that the presence of spatially separated pairs of entangled electrons, created by some *entangler*, can be revealed by using a beam splitter and by measuring the correlations of the noise fluctuations at the exiting terminals. It was later shown [4] that not only noise, but the full counting statistics is sensitive to the presence of entanglement in the incoming beam. In particular, the joint probability for counting electrons arrived at two different leads unambiguously characterizes the state of the incident electrons.

In this work we derive a Clauser-Horne-Shimony-Holt (CHSH) inequality based on the full counting statistics for electrons in multiterminal mesoscopic conductors and apply it to different systems. We first discuss the idealized situation where a incoming flux of fully entangled electrons is injected, then we move on to analyze actual setups such as a three terminal normal-metal stub. We find that the CHSH inequality is violated (see also [5]), proving that interacting electrons are not necessary to produce an entangled state. We also consider the case where entanglement is produced by Andreev scattering in a hybrid normal-metal/superconductor multiterminal system.

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